THE GEO-CODED MODEL BASED ON GEOGRAPHICAL KNOWLEDGE FORMALIZATION

(Professor) Ma Ainai
(The Institute of Remote Sensing, Peking University, China)
(ISPRS Commission III)

ABSTRACT

Geographical knowledge formalization is the most important part of the design of the geographical knowledge base of Geographical Expert System (GES) . A kind of Geo-coded Model (GCM),which is composed of independent factors with geographical facts in proper order,is used as the principle of geographical knowledge formalization. There are two kinds of GCM:tree type and multi-index type model. This paper gives an essential part of GCM theory.

Key Words: Geographical knowledge formalization,Geo-coded Model,Geographical Expert System.

1. HISTORY OF GEOGRAPHY AND ITS PRESENT SITUATION

1.1 The division of general geography

Looking back on the history of geography,with the development of the science itself, there emerged division. Many kinds of branch geography, such as topography, climatology, hydrography, geomorphology, pedogeography, biogeography, sesogeography [Ma Ainai, 1987], landuse, urbangeography, agrogeography, industrial geography, and transportation geography, etc. developed very quickly, and each branch went deeper and deeper into its own field. But on the other hand,division weakened the research on the more profound relation between these branches. As a result, the comprehensive geography, synthetic geography and systematic geography remained at a superficial level.

1.2 Qualitative and quantitative description

Qualitative description still dominates the science of geography, especially the comprehensive, synthetic, and systematic geography.Some quantitative methods have been introduced into branch geography,for example, precipatation, temperature,discharge,sediment discharge, elevation, particle size distribution, pH value, vegetation coverage, sesotic depth, growing areas, crop yield, industry output value, urban expanding rate, transport mileage, and freight volumn,etc.But the level of quantitative varies among above subjects. Some quantitative values are very simple, such as depth, area, etc. , some quantitative value are more complex, while more advanced instrument such as mass spectrometer, chromatogram are employed. So, qualitative and quantitative level are quite different.

1.3 Different expert has his own idea

Division also gives rise to all kinds of experts, whose research works are expressed in thematic maps. While different expert has his own thoughts on the classification, thematic maps on the same subject in the same area is expressed in different ways. In spite of the existence of some standards (e.g. Land Use Standard of the United Nations, the Standard of the Geology Map) , there is no uniform standard which can be used conveniently for experts in different fields. However, these maps,which can not be unified, are being used as base maps on comprehensive, synthetic and systematic geography for nature regionalization.

2. THE SITUATION OF APPLIED REMOTE SENSING

Systematic mapping is being worked on all over the world now. Using common topographic map and remote sensed image, experts from different fields congregate together to achieve their interpreted maps. As mentioned above, the maps thus produced from the same basic maps varies with experts, and levels of the development of the subject.And even an expert can reach different result maps at different times. Being input to the GIS and becoming the content of the graphic data base, the sysmetic maps can only be used to induce new information based on the conditional model. The problems are: the thematic maps, such as geomorphological map, pedological map vegetation map, etc. all are not composed of independent factors, (see paragraph 4) , thus one factor has been input more than once so graphic data is made redundant and polygons of differen thematic maps inconsistent. To make things even worse, such kind of map series lacks quantitative information and the overlay between them doesn't make much sense. Under such circumstances,why do we still insist inputing so many thematic maps into the GIS, and not seek a way more meaningful ?

3.THE SITUATION OF COMPUTER UTILIZATION

With the utilization of computer in the field of geography, such as Image Processing System (IPS), Geographical Information System (GIS), Geographical Expert System (GES) and Computer Aided Mapping (CAM) developed. Nowadays, not only data,but also knowledge can be processed with the computer. So the introduction of computer into geography not only means the increase of efficiency, but essentially the quantification and formalization of geography.

Geographical data (GD) , which is composed of the attribution, quantitation, situation, timeliness and relationship of geographical elements, is only the carrier-body of geographical information. Furthermore, geographical information and their relationships build up the content of geographical knowledge. At all events,we can express geographical data and knowledge using the computer. GCM,by which only a GCM map and

a GCM table used, is an excellent way to express them more consisely and expediently.

4. INTRODUCTION TO GCM [Ma Ainai,1988]

At first, independent factor, an important concept, must be defined: it is the basic element of geographic phenomenon or process, it has quantity and cannot be induced from another. For example, the elevation (h) is an independent factor, while slope is not an independent factor which is dh/ds in a contour map; The temperature (T) is an independent factor,while temperature gradient is not,because it is dT/ds in an isotherm;The velocity (v) is independent but discharge (Q= BHv) is not; The precipitation, vegetation coverage, soil depth are independent but soil erosion is not,and all that.

Last but not least, no thematic map is a pure independent map, its factors are comprehensive,for example:

a. Climatic map, factors generally considered are:

Irradiance, Temperature, Precipitation, Evaporation, Elevation,etc.

b. Hydrologic map:

Elevation, Watershed,water discharge,sediment discharge,etc.

c. Vegetation map:

Temperature, Precipitation, Irradiance, Elevation, slope,aspect,Soil Granularity,Soil pH Value,Vegetation Form,Type,Coverage,etc.

d. Pedological map:

Soil Material,soil moisture,Soil granularity, Soil Temperature, Soil pH Value, Soil Fertility, Vegetation Form,Type,Coverage,soil erosion intensity, Elevation,etc.

e. Geomorphological map:

Elevation, Form, Type, Lithologic characters, Structure,Temperature, Precipitation,Dynamics Chrono-Quaternary Period,etc.

(Note: The factor whose first letter is written in caption is independent.)

The conclusion from above are:

a. There are many common factors between these thematics: such as elevation, temperature, and precipitation, etc.

b. Factors that are not independent can be induced from independent factors.

Giving these independent factors a series code according to certain law is called GEOCODE.

In the GIS, if inputing these factors instead of thematic maps into computer can reduce redundancy, an expert can choose his favorite factors to build his own map reflecting his own idea, and do other relative research work more flexibly.

5. HOW TO MAKE GCMCODE

5.1 2-D to 3-D

The toporiphic map is used to be registered with remote sensed image, so that two-dimensional information is expanded to a three-dimensional one.

5.2 Table of indepent factors

As above factors, some have quantitative values, some have qualitative ones. And certain grade must be given to classify the independent factors.

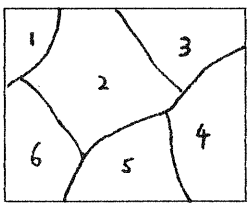
5.3 GCM map and and GCM table

GCM includes a GCM table and a GCM map (map of the smallest polygon) . There has been a method which uses certain squared area to be something like the smallest polygon as has mentioned above. But being an artificial one, this kind of squared area doesn't represent the polygon which really exists, and as a result, this method has a low precision. But our smallest polygon is a representation of certain real area which has common factors, thus the GCM map is more reasonable.

Factors of GCM table:

	El (m)	% Vc	sd (cm)
1	< 50	> 90	<20
2	50 -- 200	70 -- 90	20 -- 40
3	200 -- 500	50 -- 70	40 -- 60
4	500 -- 1000	30 -- 50	60 -- 100
5	1000 -- 1500	10 -- 30	>100
6	>1500	<10	

Polygons of GCM map:



GCM table:

No.	(1st) El	(2nd) Vc	(3rd) sd	(4th).
A	1	4	2	
B	2	4	2	
C	3	3	1	
D	4	3	2	
E	5	2	2	

El: elevation (m)
Vc: vegetation coverage (%)
Sd: Soil depth (cm)

5.4 Tree type and multi-index type

The Code has two types: tree-type and multi-index type. tree-type, e.g.in land use:

1. cultivated land
   11. irrigated field
   ...
   12. dry land
      121. slope angle <3 dgree
      122. slope angle >3 && <5 dgree
      ...
2. garden
   ...
3. woodland
   ...
4. grassland
   ...

All classifying proccess can be made into a tree-type form. Multi-index type,e.g.in soil erosion [Ma Ainai, 1989]:

Digit Code	1st	2st	3st	4st
	Erosion Intensity T/km.yr	Anti-erosion years yr	Erosion Type Dynamic	Soil Texture 2cm%
1	<500	>1000	Water	>70
2	500-2500	100-1000	Wind	30-70
3	2500-5000	10-100	Frost	<30
4	5000-8000	1-10		
5	8000-15000	<1		
6	>15000			

Erosion Intensity: 1=lowest, 2=lower,3=low,4=high,5=high,and 6=highest Anti-erosion year:1=safe, 2=dangerous, 3=more dangerous, 4=more dangerous, 5=damage

Soil texture: 1=stony,2=stony-soil and 3=soil Base level of erosion:1=plain,2=plateau and 3=very high plateau

Elevation:1=basin plain,vally,low lying land, 2=hilly land, platform,3=low moutain,4=middle moutain,5=high mountain,6=very high mountain

Vegetation coverage: 1=highest, 2=higher, 3=high,4=low,5=lower,6=lowest In the above,some factors are quatitative, the others are qualitative,both are graded somehow.

The Geo-Coded Model sometimes is a tree type, sometimes is a multi-index, sometimes also is the mixed tree and multi-index type:

6. THE APPLICATION OF GCM TO THE USE OF GIS AND GES

With the method of GCM, GIS have produced Map of Soil Erosion of China, and GCM is being applied the Yangpu developing region in Hainan Province, the watershed of river Kou, flood forcasting of Songliao Plain, and monitoring of drought of Huanghuaihai Plain with the aid of GIS and GES.

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